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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Becker, et al	Group Art Unit: Unknown
Serial No.: Unknown	Examiner: Unknown
Filed: July 9, 2001 (filed herewith)	Atty. Dkt. No.: UTXC:569USC1/MCB
For: METHOD AND APPARATUS FOR PROGRAMMABLE FLUIDIC PROCESSING	

PRELIMINARY AMENDMENT

Commissioner for Patents
Washington, D.C. 20231

Commissioner:

Please amend this application as follows:

In The Specification

At page 2, line 1, insert the following paragraph:

-- This is a continuation of co-pending application Serial No. 09/249,955, filed February 12, 1999. --

In the Claims

Please cancel claims 9-19 and 29-41 without prejudice.

Please amend claims 1-8, 20-22, and 24-28 as follows:

1. (Amended) An apparatus for programmably manipulating a plurality of packets, said apparatus comprising:

a reaction surface configured to provide an interaction site for said packets;

an inlet port coupled to said reaction surface and configured to introduce said packets onto said reaction surface;

means for generating programmable manipulation forces upon said packets, said forces capable of programmably moving said packets about said reaction surface along arbitrarily chosen paths;

a position sensor coupled to said reaction surface and configured to track positions of individual packets on said reaction surface; and

a controller coupled to said means for generating programmable manipulation forces and to said position sensor, said controller configured to adjust said programmable manipulation forces according to said positions so that said packets move along said arbitrarily chosen paths.

2. (Amended) The apparatus of claim 1, further comprising an outlet port coupled to said reaction surface and configured to collect said packets from said reaction surface.

3. (Amended) The apparatus of claim 1, wherein said means for generating manipulation forces comprises a conductor adapted to generate an electric field.

4. (Amended) The apparatus of claim 1, wherein said means for generating manipulation forces comprises a light source.

5. (Amended) The apparatus of claim 1, wherein said manipulation forces comprise a dielectrophoretic force, an electrophoretic force, an optical force, a mechanical force, or any combination thereof.

6. (Amended) The apparatus of claim 1, wherein said position sensor comprises a plurality of conductors configured to measure an electrical impedance of said packets.

7. (Amended) The apparatus of claim 1, wherein said position sensor comprises an optical system configured to monitor said positions of individual packets.

8. (Amended) The apparatus of claim 1, wherein said means for generating programmable manipulation forces and said position sensor are integral.

20. (Amended) A method for manipulating a plurality of packets, comprising:

providing a reaction surface, an inlet port coupled to said reaction surface, means for generating programmable manipulation forces upon said packets, a position sensor coupled to said reaction surface, and a controller coupled to said means for generating programmable manipulation forces and to said position sensor;

introducing one or more materials onto said reaction surface with said inlet port;

compartmentalizing said one or more materials to form said packets;

tracking positions of individual packets with said position sensor;

applying programmable manipulation forces on one or more of said packets with said means for generating programmable manipulation forces, said programmable manipulation forces being adjustable according to said positions by said controller; and

programmably moving one or more of said packets according to said programmable manipulation forces along arbitrarily chosen paths.

21. (Amended) The method of claim 20, wherein said packets comprise a fluid packet, an encapsulated packet, or a solid packet.

22. (Amended) The method of claim 20, wherein said compartmentalizing comprises suspending material in a partitioning medium.

24. (Amended) The method of claim 22, wherein said reaction surface includes a coating, and the hydrophobicity of said coating is greater than the hydrophobicity of said partitioning medium.

25. (Amended) The method of claim 20, wherein said applying programmable manipulation forces comprises applying a driving signal to one or more driving electrodes arranged in an array to generate said programmable manipulation forces.

26. (Amended) The method of claim 20, wherein said programmable manipulation forces comprise a dielectrophoretic force, an electrophoretic force, an optical force, a mechanical force, or any combination thereof.

27. (Amended) The method of claim 20, wherein said sensing comprises applying a sensing signal to one or more impedance sensing electrodes arranged in an array to detect impedances associated with said packets.

28. (Amended) The method of claim 20, further comprising interacting one or more of said packets, wherein said interacting comprises moving, fusing, merging, mixing, reacting, metering, dividing, splitting, sensing, collecting, or any combination thereof.

REMARKS

The active claims in this case are claims 1-8 and 20-28. Favorable consideration is respectfully requested.

Applicants respectfully submit that the subject matter of claims 1-8 and 20-28 is patentable for at least the reasons set forth during prosecution of the parent application, Serial No. 09/249,955. There, it was explained that cited art did not disclose, teach or suggest programmable movement along arbitrarily chosen paths or tracking individual packet positions for motion along arbitrarily chosen paths. In particular, Applicants presented the following type of arguments during prosecution of the parent case, which resulted in a notice of allowance.

1. Arbitrarily Chosen Paths

Independent claims 1 and 20 recite that packets may be programmably moved about the reaction surface *along arbitrarily chosen paths*. These features allow the present invention to

advantageously overcome several problems that exist in traditional microfluidic devices. In particular, the present invention overcomes many, if not all, of the problems stated at page 2, line 18 through page 3, line 3, where it is stated:

> A current approach to fluidic and microfluidic processing utilizes a number of *microfluidic channels* that are configured with microvalves, pumps, connectors, mixers, and detectors. While devices using micro-scale implementations of these traditional approaches may exhibit at least a degree of utility, vast room for improvement remains. For instance, pumps and valves used in traditional fluidic transportation are mechanical. Mechanical devices, particularly when coupled to thin microchannels, may be *prone to failure or blockage*. In particular, thin channels may become narrowed or partially-blocked due to buildup of channel contamination, which, in turn, may lead to mechanical failure of associated devices. Current microfluidic devices also *lack flexibility*, for they rely upon a *fixed pathway* of microchannels. With fixed pathways, devices are limited in the number and type of tasks they may perform. Also, using fixed pathways makes many types of metering, transport, and manipulation difficult. With traditional devices, it is *difficult to partition* one type of sample from another within a channel.

[(emphasis added)].

Involving the ability for programmable movement along arbitrarily chosen paths, the present invention also provides for great flexibility. In particular, the invention allows one to programmably move particles so that their paths have

> ... any shape about the reaction surface. Arbitrarily chosen paths are *not limited to movements that are predefined.* Arbitrarily chosen paths may be modified in an unlimited manner about the reaction surface and may hence trace out any pattern.

[*See* specification, page 5, lines 25-29 (emphasis added)].

These features of amended independent claims 1 and 20 are not disclosed or suggested in the cited art of the parent patent application, taken alone or in any combination.

2. Tracking Individual Packet Positions for Motion along Arbitrarily Chosen Paths

Independent claims 1 and 20 recite that the positions of individual packets may be tracked. The individual packet positions subsequently may be used to ensure that one or more

packets move along arbitrarily chosen paths. As may be gleamed from the specification, these features represent a significant advancement over traditional technology, allowing for very flexible microfluidic processing capabilities.

These features are absent from the cited art of the parent patent application, taken alone or in any combination.

CONCLUSION

Applicants respectfully request that all claims pending in this continuation patent application be allowed to swiftly pass to issuance.

Should the Examiner desire to discuss the subject matter of this preliminary amendment, please contact the undersigned attorney at 512-536-3018.

Respectfully submitted,

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APPENDIX A—AMENDMENTS MADE HEREIN

1. (Amended) An apparatus for programmably manipulating a [packet] plurality of packets, said apparatus comprising:

a reaction surface configured to provide an interaction site for said [packet] packets;

an inlet port coupled to said reaction surface and configured to introduce said [packet] packets onto said reaction surface;

means for generating [a] programmable manipulation [force] forces upon said [packet] packets, said forces capable of [to] programmably [move] moving said [packet] packets about said reaction surface along arbitrarily chosen paths; [and]

a position sensor coupled to said reaction surface and configured to [sense a position] track positions of [said packet] individual packets on said reaction surface; and

a controller coupled to said means for generating [a] programmable [manipulating force] manipulation forces and to said position sensor, said controller configured to adjust said programmable manipulation [force] forces according to said [position] positions so that said packets move along said arbitrarily chosen paths.

2. (Amended) The apparatus of claim 1, further comprising an outlet port coupled to said reaction surface and configured to collect said [packet] packets from said reaction surface.

3. (Amended) The apparatus of claim 1, wherein said means for generating [a] manipulation [force] forces comprises a conductor adapted to generate an electric field.

4. (Amended) The apparatus of claim 1, wherein said means for generating [a] manipulation [force] forces comprises a light source.

5. (Amended) The apparatus of claim 1, wherein said manipulation [force] forces [comprises] comprise a dielectrophoretic force, an electrophoretic force, an optical force, a mechanical force, or any combination thereof.

6. (Amended) The apparatus of claim 1, wherein said position sensor comprises a [conductor] plurality of conductors configured to measure an electrical impedance of said [packet] packets.

7. (Amended) The apparatus of claim 1, wherein said position sensor comprises an optical system configured to monitor said [position] positions of [said] individual [packet] packets.

8. (Amended) The apparatus of claim 1, wherein said means for generating [a] programmable manipulation [force] forces and said position sensor are integral.

9. (Canceled) An apparatus for microfluidic processing by programmably manipulating packets, said apparatus comprising:

a reaction surface configured to provide an interaction site for said packets;

an inlet port coupled to said reaction surface and configured to introduce said packets onto said reaction surface;

an array of driving electrodes coupled to said reaction surface and configured to generate a programmable manipulation force upon said packets to direct said microfluidic processing by moving said packets along arbitrarily chosen paths; and

an array of impedance sensing electrodes coupled to said reaction surface and configured to sense a position of said packet during said microfluidic processing.

10. (Canceled) The apparatus of claim 9, further comprising an outlet port coupled to said reaction surface and configured to collect said packets from said reaction surface.

11. (Canceled) The apparatus of claim 9, further comprising a controller coupled to said array of driving electrodes and to said array of impedance sensing electrodes, said controller adapted to provide a feedback from said array of impedance sensing electrodes to said array of driving electrodes.

12. (Canceled) The apparatus of claim 9, wherein said array of driving electrodes and said array of impedance sensing electrodes are integral.

13. (Canceled) The apparatus of claim 9 further comprising an integrated circuit coupled to said array of driving electrodes and to said array of impedance sensing electrodes.

14. (Canceled) The apparatus of claim 9 further comprising a coating modifying a hydrophobicity of said reaction surface.

15. (Canceled) The apparatus of claim 9, further comprising a maintenance port.

16. (Canceled) An apparatus for processing packets in a partitioning medium, said apparatus comprising:

a chamber configured to contain said packets and said partitioning medium;

a programmable dielectrophoretic array coupled to said chamber and configured to generate a programmable dielectrophoretic force to direct processing of said packets; and

an impedance sensing array of electrodes integral with said programmable dielectrophoretic array, said impedance sensing array of electrodes configured to sense a position of said packets within said chamber.

17. (Canceled) The apparatus of claim 16, further comprising an integrated circuit coupled to said programmable dielectrophoretic array and to said impedance sensing array of electrodes.

18. (Canceled) The apparatus of claim 16, further comprising a controller coupled to said programmable dielectrophoretic array and to said impedance sensing array of electrodes, said controller adapted to provide a feedback from said impedance sensing array of electrodes to said programmable dielectrophoretic array.

19. (Canceled) The apparatus of claim 16, wherein said electrodes are between about 1 micron and about 200 microns and are spaced between about 1 micron and about 200 microns.

20. (Amended) A method for manipulating a [packet] plurality of packets, comprising:

providing a reaction surface, an inlet port coupled to said reaction surface, means for generating [a] programmable manipulation [force] forces upon said [packet] packets, a position sensor coupled to said reaction surface, and a controller coupled to said means for generating [a] programmable manipulation [force] forces and to said position sensor;

introducing [a material] one or more materials onto said reaction surface with said inlet port;

compartmentalizing said [material] one or more materials to form said [packet] packets;

[sensing a position of said packet] tracking positions of individual packets with said position sensor;

applying [a] programmable manipulation [force] forces on one or more of said [packet] packets [at said position] with said means for generating [a] programmable manipulation [force] forces, said programmable manipulation [force] forces being adjustable according to said [position] positions by said controller; and

programmably moving one or more of said [packet] packets according to said programmable manipulation [force] forces along arbitrarily chosen paths.

21. (Amended) The method of claim 20, wherein said [packet comprises] packets comprise a fluid packet, an encapsulated packet, or a solid packet.

22. (Amended) The method of claim 20, wherein said compartmentalizing comprises suspending [said] material in a partitioning medium.

24. (Amended) The method of claim 22, wherein said reaction surface includes a coating, and [a] the hydrophobicity of said coating is greater than [a] the hydrophobicity of said partitioning medium.

25. (Amended) The method of claim 20, wherein said applying [a] programmable manipulation [force] forces comprises applying a driving signal to one or more driving electrodes arranged in an array to generate said programmable manipulation [force] forces.

26. (Amended) The method of claim 20, wherein said programmable manipulation [force] forces [comprises] comprise a dielectrophoretic force, an electrophoretic force, an optical force, a mechanical force, or any combination thereof.

27. (Amended) The method of claim 20, wherein said sensing [a position] comprises applying a sensing signal to one or more impedance sensing electrodes arranged in an array to detect [an impedance] impedances associated with said [packet] packets.

28. (Amended) The method of claim 20, further comprising interacting [said packet] one or more of said packets, wherein said interacting comprises moving, fusing, merging, mixing, reacting, metering, dividing, splitting, sensing, collecting, or any combination thereof.

29. (Canceled) A method of fluidic processing, said method comprising:

providing a reaction surface, an inlet port coupled to said reaction surface , an array of driving electrodes coupled to said reaction surface, and an array of impedance sensing electrodes coupled to said reaction surface;

introducing one or more materials onto said reaction surface with said inlet port;

compartmentalizing said one or more materials to form a plurality of packets;

applying a sensing signal to one or more of said impedance sensing electrodes to determine a position of one or more of said plurality of packets; and

applying a driving signal to one or more of said driving electrodes to generate a programmable manipulation force on one or more of said plurality of packets at said position; and

interacting one or more of said plurality of packets according to said programmable manipulation force.

30. (Canceled) The method of claim 29, wherein at least one of said plurality of packets comprises a fluid packet, an encapsulated packet, or a solid packet.

31. (Canceled) The method of claim 29, wherein said sensing signal and said driving signal comprise a single processing signal.

32. (Canceled) The method of claim 31, wherein said processing signal comprises a first frequency component corresponding to said sensing signal and a second frequency component corresponding to said driving signal.

33. (Canceled) The method of claim 29, further comprising forming a packet distribution map according to said positions of said plurality of packets.

34. (Canceled) The method of claim 29, further comprising determining a position of one or more obstructions on said reaction surface.

35. (Canceled) The method of claim 29, wherein said interacting comprises moving, fusing, merging, mixing, reacting, metering, dividing, splitting, sensing, collecting, or any combination thereof.

36. (Canceled) A method for manipulating one or more packets on a reaction surface, comprising:

providing a programmable dielectrophoretic array coupled to said reaction surface and an impedance sensing array of electrodes integral with said programmable dielectrophoretic array;

introducing a material onto said reaction surface;

compartmentalizing said material to form said one or more packets;

specifying a path upon said reaction surface;

applying a programmable manipulation force with said programmable dielectrophoretic array on said one or more packets to move said one or more packets along said path;

sensing a position of said one or more packets with said impedance sensing array of electrodes;

monitoring whether said position corresponds to said path; and

interacting said one or more packets.

37. (Canceled) The method of claim 36, wherein at lease one of said one or more packets comprises a fluid packet, an encapsulated packet, or a solid packet.

38. (Canceled) The method of claim 36, further comprising:

sensing a position of an obstruction;

determining a modified path, said modified path avoiding said obstruction; and

applying a programmable manipulation force on said one or more packets to move said one or more packets along said modified path.

39. (Canceled) The method of claim 36, wherein said specifying a path comprises specifying an initial position and a final position.

40. (Canceled) The method of claim 36, wherein said introducing a material comprises extracting said material with a dielectrophoretic extraction force from an injector onto said reaction surface.

41. (Canceled) The method of claim 36, wherein said interacting comprises moving, fusing, merging, mixing, reacting, metering, dividing, splitting, sensing, collecting, or any combination thereof.

APPENDIX B— PENDING CLAIMS

1. An apparatus for programmably manipulating a plurality of packets, said apparatus comprising:

a reaction surface configured to provide an interaction site for said packets;

an inlet port coupled to said reaction surface and configured to introduce said packets onto said reaction surface;

means for generating programmable manipulation forces upon said packets, said forces capable of programmably moving said packets about said reaction surface along arbitrarily chosen paths;

a position sensor coupled to said reaction surface and configured to track positions of individual packets on said reaction surface; and

a controller coupled to said means for generating programmable manipulation forces and to said position sensor, said controller configured to adjust said programmable manipulation forces according to said positions so that said packets move along said arbitrarily chosen paths.

2. The apparatus of claim 1, further comprising an outlet port coupled to said reaction surface and configured to collect said packets from said reaction surface.

3. The apparatus of claim 1, wherein said means for generating manipulation forces comprises a conductor adapted to generate an electric field.

4. The apparatus of claim 1, wherein said means for generating manipulation forces comprises a light source.

5. The apparatus of claim 1, wherein said manipulation forces comprise a dielectrophoretic force, an electrophoretic force, an optical force, a mechanical force, or any combination thereof.

6. The apparatus of claim 1, wherein said position sensor comprises a plurality of conductors configured to measure an electrical impedance of said packets.

7. The apparatus of claim 1, wherein said position sensor comprises an optical system configured to monitor said positions of individual packets.

8. The apparatus of claim 1, wherein said means for generating programmable manipulation forces and said position sensor are integral.

20. A method for manipulating a plurality of packets, comprising:

providing a reaction surface, an inlet port coupled to said reaction surface, means for generating programmable manipulation forces upon said packets, a position sensor coupled to said reaction surface, and a controller coupled to said means for generating programmable manipulation forces and to said position sensor;

introducing one or more materials onto said reaction surface with said inlet port;

compartmentalizing said one or more materials to form said packets;

tracking positions of individual packets with said position sensor;

applying programmable manipulation forces on one or more of said packets with said means for generating programmable manipulation forces, said programmable manipulation forces being adjustable according to said positions by said controller; and

programmably moving one or more of said packets according to said programmable manipulation forces along arbitrarily chosen paths.

21. The method of claim 20, wherein said packets comprise a fluid packet, an encapsulated packet, or a solid packet.

22. The method of claim 20, wherein said compartmentalizing comprises suspending material in a partitioning medium.

23. The method of claim 22, wherein said material is immiscible in said partitioning medium.

24. The method of claim 22, wherein said reaction surface includes a coating, and the hydrophobicity of said coating is greater than the hydrophobicity of said partitioning medium.

25. The method of claim 20, wherein said applying programmable manipulation forces comprises applying a driving signal to one or more driving electrodes arranged in an array to generate said programmable manipulation forces.

26. The method of claim 20, wherein said programmable manipulation forces comprise a dielectrophoretic force, an electrophoretic force, an optical force, a mechanical force, or any combination thereof.

27. The method of claim 20, wherein said sensing comprises applying a sensing signal to one or more impedance sensing electrodes arranged in an array to detect impedances associated with said packets.

28. The method of claim 20, further comprising interacting one or more of said packets, wherein said interacting comprises moving, fusing, merging, mixing, reacting, metering, dividing, splitting, sensing, collecting, or any combination thereof.